National Aeronautics and Space Administration

Flight Opportunities Program

Office of the Chief Technologist

Suborbital RLV Capabilities Matrix

More information: http://flightopportunities.nasa.gov

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	Lynx	**New Shepard**	**SpaceShipTwo**	**Super Mod** (likely to be phased out)	**Xaero**
	XCOR Aerospace	Blue Origin	Virgin Galactic	Armadillo Aerospace	Masten Space Systems
Development Status					
Vehicle	Under development	Under development	Under development	**Test flights available**	**Test flights available**
First Program Flights	tbd	tbd	tbd	**FY2011**	**March 2011**
Company					
Company	XCOR Aerospace	Blue Origin	Virgin Galactic	Armadillo Aerospace	Masten Space Systems
Address	1314 Flightline Mojave, CA 93502	21218 76th Avenue S. Kent, WA 98032 R&D Facility: West Texas Launch Site Culberson County, TX	-	2455 Ridge Rd; Suite 251 Rockwall, TX 75087 R&D Facility: Caddo Mills Municipal Airport; Bldg A Caddo Mills, TX 75135	1570 Sabovich Street Mojave, CA 93501
Point of Contact	Andrew Nelson (617) 899-8873 (cell) anelson@xcor.com	Dr. Alan Stern, Blue Origin independent representative for research applications (303) 324-5269 (office) astern@blueorigin.com	-	Neil Milburn, VP of Program Management (214) 475-1360 (cell) neil@armadilloaerospace.com	Colin Ake, Director of Business Development (678) 551-2253 (cell) cake@masten-space.com
Founded	1999	2000	2004	2000	2004
URL	www.xcor.com	www.blueorigin.com	www.virgingalactic.com	www.armadilloaerospace.com	www.masten-space.com




Vehicle specifications

Designation	Mark II [Mark I]	New Shepard	SpaceShipTwo	Super Mod	Xaero
Description	Small vehicle carrying two people in a suborbital trajectory	Crew Capsule stacked on top of the Propulsion Module. Crew Capsule can be jettisoned during flight	Spaceflight vehicle air-launched from carrier vehicle and rocket motor driven to follow typical ballistic arc	Two stacked tank configuration	Two stacked tank configuration
Type	HTHL	VTVL	HTHL	VTVL	VTVL
Propellant	-	Rocket propellant grade kerosene	-	LOX	-
Oxidizer	-	90% concentration hydrogen peroxide	-	Ethanol	-
Mode of operation	Piloted	Unpiloted (first flights)	Piloted	Remotely operated	Remotely operated
Power	28 VDC	28 VDC	-	28 VDC	12/24 VDC
Telemetry	9.6 Kbps TM/TC	1 Mbps	-	1 Mbps (downlink)	is coming
Data storage	Not provided	> 250 Gb	-	Can be provided	Not provided

					
	Lynx Mark II [Mark I]	**New Shepard**	**SpaceShipTwo**	**Super Mod**	**Xaero**
Flight Operations					
Flight profile	See Trajectory Profile in public RFI	Launch vertically, ascend to suborbital altitudes to carry both people and experiments to space, then perform a powered vertical landing for recovery and reuse of vehicle	See Trajectory Profile in public RFI	Launched vertically, coast to apogee, freefall descent, recovery by drogue and powered vertical landing	Takes off and lands vertically. Flight profile consists of launch, acceleration to Mach 0.9, full throttle until MECO, coast phase. Vehicle stabilizes upon re-entry, falls back and lands
Researcher astronauts	1 passenger / 1 pilot	3 or more	6 passengers / 2 pilots	-	-
Maximum altitude	>100 km [>61 km]	100 km	110 km	40 km (initial flights)	30 km (initial flights)
Typical flight duration	30-45 minutes	~ 10 minutes	~ 90 minutes	~ 20 minutes	5-6 minutes @ 30 km
Microgravity level	Less than 0.01 g	Less than 0.001 g	tbd	No pointing or specific attitude required 0.001 g. Pointing or attitude will reduce quality.	< 0.001 g
Typical duration of microgravity	186 sec [56 sec]	~ 3 or more minutes	~ 4 minutes	~ 3 minutes @ 100 km	12.5/5.1 sec (10/40 kg)

Flight Operations (continued)

	Lynx Mark II [Mark I]	New Shepard	SpaceShipTwo	Super Mod	Xaero
Reduced gravity capability	yes	-	-	Capable with agreement	yes, lunar/martian (add-on service)
Pointing accuracy	+/- 0.5 deg [2 deg]	Point within +/- 5 deg of commanded hold position. Limit rotation rates to less than 5 deg/sec	-	Accuracy +/- 5 degrees absolute. Rate +/-0.5 degrees/second Higher degrees of absolute pointing accuracy are possible by agreement.	All vehicles can be pointed +/-2.5 deg in any direction during coast phase (period of 1e-3 g). Intend is to develop free floating and/or vibration isolation mechanisms for P/L to have sub-arc-second pointing accuracy sometime in 2011/2012 depending on demand.
Normal operating pressure	10.5 psi +/- 0.4 psi (21% O2, 79% N2)	11 - 14 psia	-	Atmospheric ~14.5 psia	unpressurized payload bay. P/L can be self-pressurized
Normal operating temperature	-	comfortable crew habitation	-	-	-
Planned frequency of flights	1 flight / day (first months) 3 flights / day (after 1 yr) 4 flights / day (standard)	52 launches per year	2 flights / day (designed for) 1 flight / week (initial ops) 3 flights / week (end of yr 1) 1 flight / day (within 2 yrs) +1 flight / day (within 3 yrs) 3 hrs turnaround back-to-back (end)	2-3 times per week on average with multiple flights in a single day	Launch windows available on demand with very short lead time. Turn time between flights is limited only by refueling time, airspace availability, and P/L integration. Current turn around time =1 hour (excl P/L changes)

Flight Operations (continued)

	Lynx Mark II [Mark I]	New Shepard	SpaceShipTwo	Super Mod	Xaero
P/L access BEFORE flight	For internal, through main entry doors. For external, hands on access at P/L locations	Prepared CPB delivered to launch site. Data consoles available for telemetry monitoring during pre-flight, flight and post-flight operations	yes	Approx one hour before launch. With safety training, up to ten minutes from launch	Within hours. For immediate pre/post flight access may have additional ground support cost
P/L access DURING flight	-	yes	yes	n/a	n/a
P/L access AFTER flight	-	Shortly after flight	yes	Within 30 minutes of landing at take-off location. Can be retrieved sooner by Armadillo personnel	Within hours. For immediate pre/post flight access may have additional ground support cost
Initial Spaceport	Mojave Air and Space Port, CA	West Texas Launch Site (WTLS), Culberson County, TX	Spaceport America, NM	Spaceport America, NM	Mojave Air and Space Port, CA
Additional notes	Plug-n-Play minimal XCOR involvement missions will be roughly $50K, while more labor intensive mission will push into, or above, $100K.	-	Launch window can be tailored to the individual research and/or the experiment. System characteristics (fast turnaround) enable 'science of opportunity' type research. Down range flight trajectories may become option in the future and would support extended time at specific altitudes of interest	-	-

Flight Operations (continued)

	Lynx Mark II [Mark I]	New Shepard	SpaceShipTwo	Super Mod	Xaero
Cost **(May 2010 figures)**	$50K to $100K for science mission depending on support/integration needs Overall ranges from $5K-$500K: Secondary P/L (rideshare): $5K full one-off mission/LEOlaunch: $500K	-	-	Subject to vehicle used and mission profile. 200-kg to 100-km unpiloted $250K Partial payload on shared ride $10-50K	$20,000-$150,000 per flight Depends on launch location, insurance, altitude, range fees etc. Flights will gradually increase in both P/L capability and altitude. Pricing for certain test flights are negotiated on case-by-case basis

					
	Lynx Mark II [Mark I]	**New Shepard**	**SpaceShipTwo**	**Super Mod**	**Xaero**
Payload information					
General	2 primary P/L spaces and 3 secondary P/L spaces per flight Internal - primary: right seat - secondary:aft of pilot seat External - primary: dorsal pod - secondary: port & starboard aft fairing ports See schematics in public RFI	Cabin Payload System (CPS) racks, each divided into standard modular Cabin Payload Bays (CPBs)	Internal - pressurized - Typical 'direct passenger replacement' type payloads. Details to be provided when available. VG willing to work with customers to accommodate different types of payloads and racks. SS2 has large volume, substantial payload capacity, and multiple windows External - unpressurized bays for direct access to space environment	Rack system or custom mount. Customer provided utilities or Armadillo Aerospace. Payload integration can be sole ride or shared ride.	Xaero is first vehicle to use aeroshell. Current design of standard payload I/F: - P-POD Cubesat carriers - single ESPA ring mounts Lower bays limited in size and do not adhere to any existing payload interface standard.
Payload spaces per flight	2 internal/3 external Options: cannot fly 2 primary at same time. Can fly 1 primary with 3 secondary	3 or more Cabin Payload System (CPS) racks (traded with astronauts)	Passenger seats can be replaced for payload	Subject to Agreement	Forward section of nose cone and smaller areas towards aft of vehicle. Forward section P/L allows for P-POD Cubesat carriers and single ESPA ring mounts as standard P/L format. Lower bays (aft) are limited in size and have no exisiting P/L I/F

Payload information (continued)

	Lynx Mark II [Mark I]	New Shepard	SpaceShipTwo	Super Mod	Xaero
Mass (int/ext)	Internal: 120 [120] kg External: 650 [280] kg (w/o participant)	11.3 kg/CPB or 22.7 kg/double-ht. CPB	-	200-kg to 100-km. By agreement subject to experiment	Internal: 10 kg @ 30 km see public RFI for graphs
Internal volume	Primary: 120 kg / 0.17m3 Options for right seat: - human in pressure suit - Standard 19" 14U rack: 41cm depth - 2 Shuttle mid-deck lockers - user provided enclosure Secondary: 20kg / 0.09m3 (behind pilot seat) 50cm height x 40.5cm width x 46cm Bottom x 16.5cm Top (see drawing in public RFI)	Each CPS rack 10.6 cu. ft. (300 liters) divided into CPB 1.8 cu. ft. (50 liters) or double-height CPB 3.6 cu. ft.	-	-	Primary: Nose cone 91 cm (36") height 46 cm (18") base diameter 23 cm (9") top diameter Secondary: smaller areas towards aft end of vehicle. There are P/L adapter facilities at the base of the vehicle and along the fuselage as well.
External volume	Primary: Dorsal Pod (top of fuselage): 76 cm diam. x 340 cm long [43 cm x 240 cm] Secondary: 3 kg (each) / 3700cm3 2 locations: port and starboard aft fairing. 20cm depth x 15cm diameter. Exposed to vacuum	Under investigation	SS2 allows P/L to be mounted in upressurized bays for research requiring direct acces to the space environment	External by agreement	-

Payload information (continued)

	Lynx Mark II [Mark I]	New Shepard	SpaceShipTwo	Super Mod	Xaero
FASTRACK compatible 3ft L x 1.5ft W x 3ft H	Internal: yes External: no	-	Internal: yes External: -	-	-
Access to external environment	2 secondary external ports exposed to environment. Dorsal port (primary external) nose door may be opened.	Under study	yes	yes	yes
Windowed access to outside	Windows in dorsal pod can be designed at cost to customer	Windows available. Experiments can be positioned to optimize window access. Exploring possibility of externally mounted payloads that don't violate outer mold line.	multiple windows	yes	Xaero does not have standard mechanisms for providing fields of view outside the vehicle. No windows are planned.
Maximum vibration to design for	approx <1% peak-to-peak of total thrust. Acoustic levels similar to other high performance aircraft.	to be supplied at later date	-	Under investigation with NASA	-
Maximum g-load to design for	+3/-2 glimit envelope (max lift-off weight) / worst-case pullout envelope +8/-6 g (re-entry max MECO weight). Max g level at pullout 4.5g	6 g (take-off) 6 g (Flight/launch) 10 g (re-entry/landing)	4 g (flight/launch) 6 g (re-entry)	3 g 5 g (boost phase) 5 g (descent) 3 g (landing)	See g-load profiles in public RFI response

				
Lynx Mark II [Mark I]	**New Shepard**	**SpaceShipTwo**	**Super Mod**	**Xaero**

Special capabilities

General	Science flights will be same as tourism flights unless experimenter requests a change. Examples of such changes could be high alititude pointing towards chosen target, or attitude control to maintain a microgravity environment. Since vehicle has only two seats total, a science mission will be a dedicated mission unless payload is small enough to fly as a secondary payload on a tourist or other science mission.	Each CPS rack will have a separate electronics bay provided by Blue Origin that can provide power, command and control, and data recording services to exxperiments. This electronics bay will have an embedded computer that can be programmed by researchers. Blue Origin plans to provide the following electrical interfaces and services to payloads using the CPS rack: - 28V power - Analog outputs - Analog inputs - Digital I/O - RS-232 - Ehternet - Video cameras - 1 Mbps total telemetry bandwidth - Over 250 GB on-board data storage capacity		Can fly lower altitude trajectories with translation for testing hazard avoidance sensor suites. Can provide partial gravity (1/3, 1/6, ...)